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EXPERIMENTAL SPRAYING FOR THE CONTROL OF THE SPRUCE BUDWORM IN THE CODY CANYON, SHOSHONE NATIONAL FOREST 1931

By
James C. Evenden
Entomologist

Forest Insect Field Station
Coeur d'Alene, Idaho.
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INTRODUCTION

The outbreak of the spruce budworm (Cacoecia fumiferana) which has persisted for several years within the Douglas fir stands of the Cody Canyon, Wyoming, was first reported in July, 1922, and at that time was confined to one small drainage. During the past nine years this outbreak has spread over a large acreage, producing an epidemic which has been viewed with alarm by the citizens of that region. The Cody Canyon leads to the east gate of the Yellowstone National Park, which is the most popular entrance for automobile travel. This scenic canyon with its rugged mountain sides, peculiar rock formations rising for thousands of feet above the highway, through which the Shoshone River flows, depends materially upon the forests of Douglas fir as a setting or frame for its beauty. In addition to the importance of these forests to the scenic values of the canyon, there are many popular dude ranches, summer homes, and public camp grounds, which depend entirely upon these forests for the beauty of their location.

As this epidemic spread into these valuable timber stands, an insistent demand arose calling for some action to be taken to preserve the natural scenic attractiveness of the region. In 1929 a poorly planned experimental spraying project was instituted on a small scale with inadequate equipment. In 1930 a rather large scale program was carried

out with proper equipment. During the past season a more intensive program was instituted on an experimental basis and a series of different spray formulae tested. The 1931 operation was under the field supervision of Mr. B. H. Wilford, assisted by Mr. E. E. Miller, both temporary employees of the Bureau of Entomology. Credit is due these men for the splendid manner in which they conducted this project and the worthwhile data collected. The writer wishes to acknowledge the assistance rendered by Mr. A. L. Gibson of the Coeur d'Alene Station in computing the data secured during the past season's operation.

SPRUCE BUDWORM

In consideration of statements which are to follow, it would seem advisable to briefly discuss the seasonal history and feeding habits of the spruce budworm. The adult insects, which are small brownish moths with a wing expanse of approximately one inch in width, are to be seen flying in late July and early August. During this period eggs are laid in light green inconspicuous masses along the under side of the needles. These eggs hatch in 10 to 12 days, and the young larvae construct small cocoons under flakes of bark, or in other sheltered places, in which they pass the winter. It is not definitely known if these young larvae feed before hibernation or not, but if they do it is only sparingly. The following notes on the development and habits of this insect were taken by Mr. Wilford during the 1931 operation, and of course refer to conditions within the Cody Canyon.

May 15, 1931 - Small budworm larvae varying from 1¾ to 2 mm. in length were found within the 1930 needles. A small hole is chewed into the needle by the larvae which mine the central portion. Green frass is removed from the cavity and deposited around the outside of the entrance hole. Several entrance holes were found near the top of the needle; however, a majority of them were located nearer the base. Several cases were found where two or more needles were tied together with silken threads. Entrance holes are found on the under sides of the needles. Area of needle around entrance hole soon turns brown and becomes brittle.

May 16, 1931 - A few small budworm larvae were found crawling around the 1930 foliage on trees sprayed during that season.

May 20, 1931 - Larvae seem to be somewhat fatter than when recorded on the 15th. It would seem that the larvae bore into and feed within a needle until it becomes dry and begins to harden and discolor, when they leave to perhaps feed upon other needles or to enter the new buds. No record has been made of their feeding on other than 1930 foliage.

May 20, 1931 - One budworm larva was found within a Douglas fir bud. Much frass had been emitted and the bud was practically hollowed out, with but two scales remaining which covered the larva. Body of larva was of a light yellow green with a dark reddish brown head and thoracic shield. Larva measured 3 mm. in length and was very active.

May 23, 1931 - Examined 63 terminal buds and found 49 needles (1930 growth) with budworm entrance holes. One bud infested. Most of these needles were located on the south side of tree. Young larvae in web commencing an entrance hole at base of Douglas fir bud. Larvae 2½ mm. long, of a brownish red color, with dark brown head and thoracic shield.

May 25, 1931 - Young larvae found in and on needles of 1930 sprayed and unsprayed trees. More larvae on unsprayed than sprayed trees. On 100 terminal tips on sprayed trees 61 larvae were found while on 25 tips from unsprayed trees 32 were recorded. These counts made at Sunnyrest camp.

May 29, 1931 - Larvae found infesting swollen Douglas fir buds. Larvae about 4 mm. long, reddish brown in color with dark reddish thoracic shield and nearly black (dark brown) head. Entrance holes in buds are found on the side of the buds about midway between base and tip. Frass deposited on outside of entrance hole.

June 3, 1931 - Budworm larvae in swollen and bursting buds. Larvae are from 5 to 6 mm. long and quite stout. Color is from a rusty brown to olive green, with dark brown thoracic shield and head. Within the buds the larvae bore into the center of the needle cluster, turning the parts of the needles bordering the tunnel a brown color. When the buds have opened, the larvae, being in the center, bind the outside needles together forming a protective case.

June 17, 1931 - Buds were found that had been partially destroyed which contained no larvae. Apparently after partially destroying these buds the larvae had migrated to other buds where their development was completed. Larvae collected varied from 3 to 12 mm. in length, with a coloration from greyish dark brown to pea green and yellow green shades. The head and thoracic shield are usually dark reddish brown, though with a few the head was not darkened but blended with the body color.

June 26, 1931 - Larvae are apparently mature and preparing for pupation. Larvae are in webs, made by joining the needles together with silken threads. The larvae vary materially, ranging from 4 to 26 mm. in length, with many different colors. One pupa recorded.

July 2, 1931 - Seventy-five per cent of the budworm are in pupal stage. Nearly all of the remaining larvae seem to be reaching maturity and preparing for pupation, though there are still a few small larvae to be found.

July 5, 1931 - Pupae, prepupae and larvae found in abundance at Powell Colony. Parasitized larvae and pupae were rather plentiful. Birds (Chickidee) observed feeding upon larvae and pupae.

July 7, 1931 - Many parasitized larvae and pupae recorded.

July 13, 1931 - Empty pupal cases recorded.

July 18, 1931 - Egg mass on under side of needle.

July 25, 1931 - Egg mass recorded on 18th, hatched into light yellow green, brown headed larvae, about 2 mm. long.

July 29, 1931 - Above larvae changed to a bright orange color, having woven a very closely knit web about themselves. Apparently the larvae remain in this web until the following spring, when they emerge and start feeding.

After feeding starts in the spring, the larvae develop very rapidly and are usually mature by early July. When mature, the larvae are approximately one inch in length, varying in color as noted by Mr. Wilford. When mature, pupation occurs within chrysalids attached by a few silken threads to twigs and other objects. The pupal stage lasts from 10 to 12 days and there is but one generation per year. The larvae feed with their head at the base of the needles. This habit as well as

the protection afforded from the buds and webs makes it a very difficult pest to control through the application of a spray.

PAST CONTROL OPERATIONS

In view of the seriousness of the budworm epidemic which existed within the Cody Canyon, a small sum of money was made available in 1929 for the institution of some experimental work. The purpose of this small project was to determine the feasibility of destroying the feeding larvae with sprays that had proved effective against other defoliating insects. Though this project was regarded as an experiment, it actually developed into a potential control project centering around several of the dude ranches where the infestation was the heaviest. A standard lead-arsenate, fish oil spray was used, the formulae being the one giving the greatest success in the control of the gypsy moth in the eastern United States. This spray was applied with a small portable "Evinrude" forest fire pump, which was not satisfactory as sufficient power could not be developed.

Space will not be taken for a detailed account of this experiment which has been adequately covered in previously submitted reports. It is sufficient to say that the results secured were not at all satisfactory. The spraying equipment used was not efficient and, though some larval mortality was recorded soon after the trees were sprayed, later in the season it was difficult to see where any reduction in the defoliation had occurred. Though at that time it was fully realized that this insect, due to its feeding habits, would prove to be an extremely difficult pest to control, it was thought that the failure of this experimental project was

due primarily to the poor equipment used, and that far better results would have followed had the spray been properly applied.

In 1930, under a special $10,000 allotment, an extensive spraying program was instituted with the idea of protecting a strip of trees along the roadside, as well as those of perhaps higher scenic values around the dude ranches and summer homes. To carry on the project a high powered Fitzhenry Guptill Sprayer, owned by the National Park Service, was secured from the Yellowstone National Park. It was intended that this project be regarded somewhat in the light of an experimental spraying project; however, with the funds available, and the seriousness of the infestation, it quickly developed into a straight control operation with the sprayer operating 16 hours daily with little thought of experimental values. Though this development was not as desired, it was a natural occurrence, and could not be advisably avoided. During the project, which started on June 13th and closed on July 7th, there were 340 four hundred gallon tanks, or a total of 136,000 gallons, of spray applied. The standard lead-arsenate, fish oil spray was used, though a number of variations in the formulae were tested. As a rather thorough account of this operation was submitted in a report from this station under date of February 20, 1931, the details will not be repeated at this time. However, it would seem necessary to mention that the results as secured were not as satisfactory as had been expected. Due to the feeding habits of the larvae just mentioned, it was found that the insect was a great deal harder to destroy than had been anticipated. The feeding larvae could not be reached with a stomach poison until the buds in which they were concealed had opened, and after this occurred the

defoliation was very rapid. It was apparent that in the development of the new foliage, optimum conditions for the destruction of the larvae by spray would be at a time when the buds were first fully opened. This presented a difficult problem to meet as the buds in the tops of trees opened before those at the base, and with a large scale project it was impossible to treat all of the trees at a time to avoid the severe damage which occurs so quickly after the buds have opened. Furthermore, the securing of a good coverage on the new foliage, especially near the base of the needles where the larvae were feeding, proved to be a difficult task. As a result of the 1930 operation the reduction in the defoliation of treated trees varied from a negligible amount to as much as 70 per cent. Though, of course, in some areas the defoliation was reduced sufficiently to prevent permanent injury to the trees, the results were so inconsistent that the operation as conducted in 1930 could hardly be recommended as a method of control for future epidemics.

1931 OPERATION

In summarizing the control project of the 1930 season, it was evident that though the standard lead-arsenate fish oil spray gave some successful results, the treatment could hardly be recommended as a sound method of control against outbreaks of the spruce budworm. Furthermore, it was apparent that the necessity of securing a good coverage at the base of the needles, due to the peculiar feeding habits of the larvae, would make this pest a difficult one to control. With this realization, the 1931 operation was instituted on a more intensive experimental basis, and plans

developed for the testing of a number of different sprays. In planning this project, there were four phases in the seasonal history of this insect toward which control could be directed, and which seemed worthy of consideration. These phases were as follows:

1. Destruction of overwintering larvae while in their hibernacula and after emergence, but before entering terminal buds, through the use of stomach poisons and contact sprays.

2. Destruction of larvae while feeding on new growth after buds have opened through the use of stomach poisons and contact sprays.

3. Destruction of eggs through the use of an ovicide.

4. Prevention of oviposition through the use of a repellent.

Plans were made for the testing of a number of different sprays though, due to the difficulty in securing certain chemicals, it was impossible to conduct all of the tests contemplated. In carrying out this experimental program, plots were established along the roadside with check or control plots adjacent. Around the dude ranches, summer homes, etc., for which protection to the trees was especially desired, the standard lead-arsenate fish oil spray was used with the belief that it offered the best known method of control. To apply these sprays a high power Fitzhenry Guptill sprayer was transferred to the Division of Forest Insects of the Bureau of Entomology, from the Division of Cereal and Forage Insects of the same Bureau. This sprayer was similar to the one secured from the National Park Service during the previous season, with the exception that it was equipped with a 600 gallon tank instead of a 400. During the 1931 operation which cost, exclusive of overhead, $1,758.33,

there were 93 full tanks (600 gallons) and 36 part tanks (400 gallons) applied, making a total of 70,200 gallons. A more detailed record of the 1931 expenditures follows.

At the time this allotment of $10,000 was made to the Bureau of Entomology for the institution of this experimental spraying project, $7,500 was transferred to the Shoshone National Forest for administration, while $2,500 was maintained by the Bureau for the payment of salaries and expenses of men assigned to the project, purchase of equipment, etc. At the close of the 1930 season the balances of these two allotments were as follows:

Forest Service	$ 1,829.35
Bureau Entomology	1,145.02
	$ 2,974.37

ANALYSIS OF COST OF 1931 OPERATION

Disbursed by Forest Service

Labor	$ 843.00
Spray Materials	367.96
Subsistence	146.71
Freight and Express	86.98
Gas and Oil	218.28
Equipment and Repairs	91.65
Miscellaneous	3.75
	$ 1,758.33

Disbursed by Bureau of Entomology

Wilford Salary	$ 495.00
Wilford Expenses	98.57
Freight on Sprayer	443.26
	$ 1,036.83

Status of $10,000 Appropriation

	Forest Service	Bureau Entomology
Allotment	$ 7,500.00	$ 2,500.00
Disbursed 1930	5,670.65	1,354.98
Balance	1,829.35	1,145.02
Disbursed 1931	1,758.33	1,036.83
	71.02	108.19
		71.02
Balance of Appropriation		$ 179.21

Though the above figures show the total cost of the different items making up the project, it would seem that some of them should be explained in further detail.

Labor

Applying Spray	$ 524.00
Repairing Sprayer	29.00
Moving Sprayer from Cody to Wapiti	10.00
E. E. Miller Salary (May and June)	280.00
	843.00

Spray Materials

Lead Arsenate	180.39
Fish Oil	61.23
Linseed Oil	11.78
Volck	48.72
Kayso (Spreader)	3.12
Ortho Zinc Arsenate	6.00
Tanglefoot	8.25
Calcium Arsenate Dust	2.50
Barium Fluosilicate	2.52
Paint and Brush (Marking sample plots)	1.90
Pine Oil	6.05
Molasses and Muslin (Insect Traps)	10.70
Forestit	24.80
	367.96

Subsistence

Board and Expenses E. E. Miller (May and June)	146.71

Freight

Spray Materials, California Spray Company	$ 38.23
Lead Arsenate	28.27
Fish Oil	14.84
Local Hauling	5.64
	86.98

Gas and Oil

For Sprayer and Ford Truck	218.28

Equipment

Tires and Tubes (Ford Truck	17.50
Miscellaneous Pump parts and fitting	24.60
Slicker Suit	4.75
Gate Valve for Pump	12.34
Hose Connections	12.00
Low Pressure Tief Valve	5.46
Hose Gaskets and Ring	2.59
Paint for Sprayer	4.65
Repairs on Ford Truck	5.25
Agitator Shaft Bearing	2.51
	91.65

Miscellaneous

Telegrams, Telephone	3.75

Though but a small balance of this appropriation remained at the close of the fiscal year, the following assets and equipment are on hand:

Assets and Equipment on Hand

Lead Arsenate, 1250 pounds	$ 131.25
Fish Oil, 50 gallons	28.23
Worthy Nozzle (Less Depreciation of 40%)	18.62
Nozzle Tips and Straps (" " ")	8.36
Suction Hose (" " ")	8.75
High Pressure Hose (" " ")	150.80
Fitzhenry Guptill Sprayer (Value unknown)	
Ford Pickup (1930 Model)	300.00
	$ 646.01

Though the figures as used in the preceding cost analysis depict the actual expenditures of this project, there may be some slight errors in the allocation of certain expenditures due to the lack of more detailed information. However, if any such errors do exist, they will prove to be so slight that they will have little influence on the data as given.

A statistical comparison of the project for the years 1930 and 1931 follows:

Comparison of 1930 and 1931 Operations

	1930	1931
Cost of Project - - - - - - - - - - - - - - - -	$ 5,670.65	$ 1,478.33
Amount of Spray Used (Gallons) - - - - - - - -	136,000	69,400
Cost per gallon of Spray - - - - - - - - - -	$ 0.00416	$ 0.00213
Average height of trees sprayed - - - - - -	30 feet	30 feet
Average number of Trees Sprayed for 400 gallon Tank - - - - -	124	130
Gallons of Spray per Tree - - - - - - - - - -	3.22	3.07
Cost of Spraying per Average Tree - - - - - -	$ 0.133	$ 0.065
Man Days (Total Exclusive Overhead) - - - - -	374	107
Gallons of Spray per Man Day - - - - - - - -	364	648
Cost to Project per Man Day - Total - - - - -	$ 15.16	$ 13.81
Cost per Effective Man Day (Labor Subsistence)	$ 5.75	$ 5.26

In computing these costs the project has not been credited with the assets or equipment on hand which would reduce the cost of the above items rather materially.

The explanation of the reduced cost of operation in 1931 can best be attributed to the use of the sprayer equipped with a 600 gallon tank instead of the 400 gallon one used in 1930. This larger tank resulted in a marked reduction in the time lost in going to and from water. Furthermore, the equipment was in much better condition, which resulted in there being very little time lost from breakdowns. The 1931 project was also

on a much smaller scale than in 1930, which of course tends to produce a more efficient operation. Another item of saving was in the subsistence charges. In 1930 the charges against the project for subsistence were $1.44 per man day. In 1931, the project being much smaller, the men were hired at the same wage scale plus the customary dollar per day for board. This resulted in a net saving to the project of $0.44 per man day. Though these items are all small, when taken in the aggregate they result in a rather substantial reduction in the cost of an operation.

Labor Analysis

Wage Scale

Truck Driver and Mechanic	(Without board)	$ 5.00
Nozzleman	(" ")	5.00
Hosemen	(" ")	4.00

Crew Organization

1 Mechanic and Truck Driver
1 Nozzleman
5 Hosemen

In 1930 water was hauled to the 400 gallon sprayer with auxiliary tanks, which was not necessary in 1931.

ANALYSIS OF 1931 SPRAYING OPERATION

As previously stated the trees around the dude ranches and summer homes were treated with the standard lead-arsenate fish oil spray in the belief that this treatment was the best known at that time. The testing of the various combinations of spray materials was confined to sample plots located along the road side. The results of all these

treatments were checked by control plots located immediately adjacent to the sample plot. In the establishment of these plots an error was made in not marking the trees used for the pre-spraying larval examination in order that the same trees might be re-examined following the treatment. Furthermore, in the check or control plots trees should have been marked and examined, both before and after the spray plot was treated, to determine natural brood mortality. Had these data been available the natural mortality could have been weighed and a better measurement of effectiveness applied to the different treatments. Furthermore, it is unfortunate, from the standpoint of the experimental spraying, that a marked decrease in the severity of the outbreak occurred subsequent to the 1930 defoliation. This decreased defoliation made the measurement of the success of the various sprays used a very difficult task. However, the reduction in the infestation secured from these different treatments have been shown in percentages, and it can be assumed that the same, or even a larger reduction, would have resulted had the treatment been applied to more heavily infested plots.

In connection with the following sample plots, all examinations to determine the severity of the infestation prior to spraying, as well as the degree of defoliation of both sprayed and unsprayed trees, were based upon a definite number of new growth tips from the base, middle, and tops of the trees selected. Furthermore, in recording the degree of coverage secured, the terms "Poor", "Fair" and "Good" have been used. These are based upon the percentage of the foliage actually covered, and are allocated as follows:

Minus	POOR	Plus	Minus	FAIR	Plus	Minus	GOOD	Plus
0-11%	12-22%	23-33%	34-44%	45-55%	56-66%	66-77%	78-88%	89-99%

Experiment A-1

Spray Plot #1
Blackwater Lodge

May 26, 1931 - Budworm infestation heavy. An examination of 2300 new growth tips from 4 trees showed 1372 larvae, or .59 per tip.

May 30, 1931 - Area sprayed.
Formulae - Lead-arsenate 36#, fish oil 5 qts., water 600 gallons.
Foliage - Buds starting to swell, 25% open.
Weather - Clear, warm, slight wind.
Amount of spray used - 600 gallons.
Purpose of this treatment was to determine if the larvae could be destroyed after leaving their hibernacula before or as they entered the swelling buds.

June 20, 1931 - Examination of 1500 new growth tips taken from the base, middle and top of five trees showed 426 larvae, or .28 per new growth tip.

June 26, 1931 - Area resprayed.
Formulae - Lead-arsenate 24#, Volck 8 gal., water 400 gallons.
Purpose of this treatment was to attempt the destruction of the feeding larvae through the application of lead-arsenate as a stomach poison, and Volck as a contact spray.

July 7, 8, 1931 - Final examination to determine the results secured from this experiment were made from new growth tips from 4 treated and 4 untreated trees.

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERAGE

Degree of Injury		Degree of coverage trees treated: Good Tips	Fair 1207 Tips	Poor Tips	Unsprayed Trees 1453 Tips
None	No. of Tips:		462		500
	% of Tips:		38.3		34.4
0-30%	No. of Tips:		260		403
	% of Tips:		21.6		27.6
30-60%	No. of Tips:		166		142
	% of Tips:		13.7		9.8
60-90%	No. of Tips:		118		114
	% of Tips:		9.8		7.6
100%	No. of Tips:		201		294
	% of Tips:		16.6		20.5
Average Injury			33.4%		34.6%

Experiment A-1 (CONT.)

Spray Plot #1
Blackwater Lodge

The manner in which the data for this plot was taken made it necessary to place all of the examined tips from the treated trees under the classification of "Fair Coverage". However, available data does indicate that 55% of the foliage was covered, which justifies this position. From the above table it will be seen that the treated trees were 33.4% defoliated, while on the unsprayed trees adjacent the defoliation amounted to 34.6%. The difference of 1.2% in the amount of defoliation makes the effects of this treatment negligible. On August 6, 1931 a visual examination was made of these trees and no difference could be seen in the defoliation between the treated and untreated trees.

Experiment A-2

Spray Plot #2
Blackwater Camp

May 22, 1931 - Budworm infestation light. An examination of 2550 new growth tips from 11 trees showed 175 larvae, or .069 per tip.

May 30, 1931 - Area sprayed.
Formulae - Lead-arsenate 36#, fish oil 5 qts., nicotine-sulphate 4 quarts, water 600 gallons.
Weather - Clear, warm, slight wind.
Amount of spray used - 600 gallons.
Foliage - 25% of buds open.
Purpose of this experiment was to determine if, through the application of a combination stomach poison and contact spray, the larvae could be destroyed before or as they enter the swelling buds.

July 8, 1931 - Final examination to determine the results secured from the application of spray was made from new growth tips from 4 treated and 4 untreated trees.

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERAGE

Degree of Injury		Degree of coverage trees treated: Good Tips	Fair Tips	Poor 1199 Tips	July 8, 1931 Unsprayed Trees 1201 Tips
None	No. of Tips			1022	1060
	% of Tips			85.3	88.3
0-30%	No. of Tips			59	60
	% of Tips			4.9	5.0
30-60%	No. of Tips			59	39
	% of Tips			4.9	3.2
60-90%	No. of Tips			29	14
	% of Tips			2.4	1.2
100%	No. of Tips			30	28
	% of Tips			2.5	2.3
Average Injury				7.3%	5.4%

This examination shows that 7.3% of the foliage was destroyed on the treated trees while only 5.4% on the check trees adjacent. However, this difference in favor of the non-treated trees no doubt indicates uncontrollable error in the selection of trees for examination which was not absorbed in the small amount of data secured. However, it is very evident that this error would not be of sufficient magnitude to seriously affect the negligible results as shown. When examined in August, no difference could be seen between the sprayed and unsprayed trees.

Experiment B-1

Spray Plot #3
Blackwater Plot

May 29, 1931 - Budworm infestation light. An examination of 600 new growth tips from 4 trees showed 67 larvae, or .111 per tip.

June 2, 1931 - Plot 3A (early) sprayed.

June 12, 1931 - Plot 3B (medium) sprayed.

June 30, 1931 - Plot 3C (late) sprayed.

Formulae - Lead-arsenate 24#, fish oil 3 qts., water 400 gal.
Foliage - 25% of buds open.
Weather - No rain, no wind.
Amount of spray used - 1200 gallons (400 gallons to each section).

Purpose of this experiment was to determine the best time to apply a standard stomach poison spray. Plot 3 was divided into three sections and sprayed as indicated above, each section being supported with adequate check trees. Spray materials were also to be considered as a possible repellent to subsequent oviposition.

July 9, 1931 - Final results based upon examination of defoliation of new growth tips of sprayed and unsprayed trees.

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERAGE

Plot #3A - Blackwater Camp Ground

Count from 3 Trees Sprayed June 2, 1931

Degree of Injury		Degree of coverage trees treated: Good Tips	Fair Tips	Poor 914 Tips	Unsprayed Trees (6) 1223 Tips
None	No. of Tips			732	951
	% of Tips			80.1	77.8
0-30%	No. of Tips			76	82
	% of Tips			8.3	6.7
30-60%	No. of Tips			50	83
	% of Tips			5.5	6.8
60-90%	No. of Tips			25	43
	% of Tips			2.7	3.5
100%	No. of Tips			31	64
	% of Tips			3.4	5.2
Average Injury				11.4%	11.9%

Experiment B-1

Spray Plot #3
Blackwater Plot

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERAGE

Plot 3B - Blackwater Camp Ground

Count from 2 Trees Sprayed June 12, 1931

Degree of Injury		Degree of coverage trees treated: Good Tips	Fair 36 Tips	Poor 571 Tips	Total Tips 607	Unsprayed Trees (6) 1223 Tips
None	No. of Tips:		36	483	519	951
	% of Tips:			84.6	79.6	77.8
0-30%	No. of Tips:			21	21	82
	% of Tips:			3.7	3.5	6.7
30-60%	No. of Tips:			32	32	83
	% of Tips:			5.6	5.3	6.8
60-90%	No. of Tips:			13	13	43
	% of Tips:			2.3	2.1	3.5
100%	No. of Tips:			22	22	64
	% of Tips:			3.8	3.6	5.2
Average Injury			0%	8.6%	8.1%	11.9%

Plot 3C - Blackwater Camp Ground

Data from 2 Trees Sprayed June 30, 1931

Degree of Injury		Degree of coverage trees treated: Good 527 Tips	Fair 49 Tips	Poor 67 Tips	Total Tips 643	Unsprayed Trees (6) 1223 Tips
None	No. of Tips:	427	34	30	491	951
	% of Tips:	81.0	69.4	44.8	76.4	77.8
0-30%	No. of Tips:	26	7	14	47	82
	% of Tips:	4.9	14.3	20.9	7.3	6.7
30-60%	No. of Tips:	32	1	13	46	83
	% of Tips:	6.1	2.0	19.4	7.1	6.8
60-90%	No. of Tips:	13	4	7	24	43
	% of Tips:	2.5	8.2	10.4	3.7	3.5
100%	No. of Tips:	29	3	3	35	64
	% of Tips:	5.5	6.1	4.5	5.4	5.2
Average Injury		10.8%	15.3%	24.2%	12.6%	11.9%

From these data it will be seen that the results of the three tests varied but little, and that little difference existed between the treated and untreated trees though the second application does show a reduction of 32% in the defoliation of the treated trees. When examined in August, but little difference could be seen between the treated and untreated trees.

Experiment B-1

Spray Plot #4
Newton Creek Plot

June 1, 1931 - Budworm infestation light. An examination of 450 new growth tips taken from 3 trees showed 77 larvae, or .171 per tip.

June 2, 1931 - Plot 4A sprayed (early).

June 12, 1931 - Plot 4B sprayed (medium).

June 30, 1931 - Plot 4C sprayed (late).

Formulae - Lead-arsenate 2#, fish oil 3 qts., water 400 gallons.
Foliage - 25% of buds opened.
Weather - No rain, no wind.
Amount of spray used - 1200 gallons (400 gallons to each section).
Purpose of this experiment was the same as Plot #3, which was to determine the best time to apply a stomach poison spray. This plot was divided into 3 sections and sprayed as indicated above.

July 10, 1931 - Final examination based upon the difference in the defoliation of new growth tips on sprayed and unsprayed trees.

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERAGE

Plot #4A - Newton Creek

Data from 3 Trees Sprayed June 2, 1931

Degree of Injury		Degree of coverage trees treated: Good Tips	Fair Tips	Poor 911 Tips	Unsprayed Trees (4) 1292 Tips
None	No. of Tips			705	614
	% of Tips			77.4	47.6
0-30%	No. of Tips			70	220
	% of Tips			7.7	17.0
30-60%	No. of Tips			52	128
	% of Tips			5.7	9.9
60-90%	No. of Tips			24	62
	% of Tips			2.6	4.8
100%	No. of Tips			60	268
	% of Tips			6.6	20.7
Average Injury				12.3%	31.4%

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERED

Plot #4B - Newton Creek

Data from 2 Trees Sprayed June 12, 1931

Degree of Injury		Degree of coverage trees treated: Good 24 Tips	Fair 97 Tips	Poor 499 Tips	Total Tips 620	Unsprayed Trees (4) 1292 Tips
None	No. of Tips	24	80	285	389	614
	% of Tips		82.5	57.0	62.7	47.6
0-30%	No. of Tips		10	70	80	220
	% of Tips		10.3	14.0	12.9	17.0
30-60%	No. of Tips		4	65	69	128
	% of Tips		4.1	13.0	11.3	9.9
60-90%	No. of Tips			29	29	62
	% of Tips			6.0	4.7	4.8
100%	No. of Tips		3	50	53	268
	% of Tips		3.1	10.0	8.5	20.7
Average Injury		0.0%	6.5%	22.5%	19.1%	31.4%

Plot #4C - Newton Creek

Data from 2 Trees Sprayed June 30, 1931

Degree of Injury		Degree of coverage trees treated: Good 440 Tips	Fair 101 Tips	Poor 80 Tips	Total Tips 621	Unsprayed Trees (4) 1292 Tips
None	No. of Tips	400	94	77	571	614
	% of Tips	90.9	93.0	96.2	91.9	47.6
0-30%	No. of Tips	22	5	1	28	220
	% of Tips	5.0	5.0	1.2	4.5	17.0
30-60%	No. of Tips	10	2	1	13	128
	% of Tips	2.3	2.0	1.3	2.1	9.9
60-90%	No. of Tips			1	1	62
	% of Tips			1.3	.2	4.8
100%	No. of Tips	8			8	268
	% of Tips	1.8			1.3	20.7
Average Injury		3.6%	1.6%	1.7%	3.0%	31.4%

Though the budworm infestation is recorded as light, the defoliation of the untreated trees was rather severe, there being 31.4% of the foliage destroyed. On the first section of this plot (early spray) the data indicates that a reduction of 39% followed the treatment. With the second section a "Poor" coverage was secured with a reduction of 60%. With the third section "Good" coverage was secured and a reduction of 90% followed. It would seem from these data that the best results were secured from the June 30 spraying.

At the time of this late spray the foliage was fully opened and it would seem that if the best results are to be secured the trees should be treated at this time, before serious defoliation occurs. A visual examination in August showed a little difference in the defoliation of the treated and untreated trees.

Experiment B-3

Plot #5
Newton Creek, West

June 2, 1931 - Budworm infestation light. An examination of 600 new growth tips from 4 trees showed 24 larvae, or .04 per tip.

June 2, 1931 - Area sprayed.
Formulae - Lead-arsenate 24#, fish oil 3 quarts, skim milk 3 gal. water 400 gallons.
Foliage - Buds swelling and some opening.
Weather - Clear, warm, with slight wind followed by rain on June 3 and 4.
Amount of spray used - 800 gallons.

In this experiment skim milk was added to the standard lead-arsenate spray to determine if through the use of this spreader the arsenate could be placed near the base of the needles. Two treatments, early and late, were tested. Possible effects of this spray as a repellent to oviposition were also to be considered.

June 25, 1931 - An examination of 1200 new growth tips taken from 4 trees showed 35 larvae, or .03 per tip. On the date the above spray was applied an excellent spread with good adhesive properties was apparent. The foliage where sprayed was white with an even coating on all sides.

June 30, 1931 - Second spray applied.
Formulae - Lead-arsenate 24#, fish oil 3 qts., skim milk 7 gal. water 400 gallons.
Foliage - Buds fully opened.
Weather - Clear, warm, slight wind.

July 14, 1931 - Final examination to determine the results secured was based upon new growth tips from 4 treated and 4 untreated trees.

Experiment B-3

Plot #5
Old Linseed Plot

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERAGE

Degree of Injury		Degree of coverage trees treated: Good 334 Tips	Fair 294 Tips	Poor 605 Tips	Total Tips 1233	Unsprayed Trees 1221 Tips
None	No. of Tips:	295	252	547	1094	988
	% of Tips:	88.3	85.7	90.4	88.6	80.9
0-30%	No. of Tips:	15	25	28	68	77
	% of Tips:	4.5	8.5	4.6	5.5	6.3
30-60%	No. of Tips:	6	7	15	28	71
	% of Tips:	1.8	2.4	2.5	2.3	5.8
60-90%	No. of Tips:	7	3	6	16	29
	% of Tips:	2.1	1.0	1.0	1.3	2.4
100%	No. of Tips:	11	7	9	27	56
	% of Tips:	3.3	2.4	1.5	2.2	4.6
Average Injury		6.3%	5.5%	4.0%	5.0%	9.9%

From the application of this spray a "Fair" coverage was secured, and a reduction of 49% in the defoliation of the treated trees followed. However, the light infestation encountered on this plot makes the determination of the results rather difficult. A visual examination of this plot on August 6 was recorded as good coverage though very little difference could be seen in the treated and untreated trees. Though this plot was sprayed on two different dates, the data secured was not separated and it was necessary to consider them both as one plot.

Experiment B-10

Spray Plot #6
Archway

June 12, 1931 - Budworm infestation light. An examination of 600 new growth tips from 4 trees showed 22 larvae, or .037 per tip.

June 16, 1931 - Area sprayed.
Formulae - Lead-arsenate 36#, fish oil 5 qts., nicotine-sulphate 4 qts., water 600 gallons.
Foliage - Buds all opened.
Weather - Hot, no wind.
Amount of spray used - 600 gallons.
The purpose of this experiment was to attempt a combination stomach poison and contact spray. It was also thought the nicotine-sulphate might act as a repellent to subsequent oviposition.

July 9, 1931 - Final examination to determine the results from this treatment was made from new growth tips from 5 treated trees and 4 untreated trees.

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERAGE

Degree of Injury		Degree of coverage trees treated: Good 141 Tips	Fair 409 Tips	Poor 1007 Tips	Total Tips 1557	Unsprayed Trees 1227 Tips
None	No. of Tips:	126	366	893	1385	1076
	% of Tips:	89.4	89.5	88.6	89.0	88.6
0-30%	No. of Tips:	7	23	49	79	73
	% of Tips:	5.0	5.6	4.9	5.1	6.0
30-60%	No. of Tips:	5	8	28	41	39
	% of Tips:	3.5	2.0	2.8	2.6	3.2
60-90%	No. of Tips:	1	6	15	22	24
	% of Tips:	.7	1.5	1.5	1.4	2.0
100%	No. of Tips:	2	6	22	30	15
	% of Tips:	1.4	1.4	2.2	1.9	1.2
Average Injury		4.3%	4.3%	5.3%	4.9%	5.0%

This treatment with only an average coverage of "Poor plus" showed practically no difference (2%) in the defoliation of the treated and untreated trees. However, with such light infestation the results of treatment are indeed difficult to determine. A visual examination of this plot on August 6 revealed but very little difference in the defoliation of treated and untreated trees.

Experiment B-2

Spray Plot #7
Newton Creek South

June 3, 1931 - Budworm infestation medium. An examination of 900 new growth tips showed 309 larvae, or .343 per tip.

June 11, 1931 - First section of area sprayed.
Formulae - Lead-arsenate 24#, linseed oil 3 qts., water 400 gal.
Foliage - Buds opened. Foliage fully out.
Weather - Hot, strong wind.
Amount of spray used - 400 gallons.
The purpose of this experiment was to determine if a better coverage could be secured with linseed oil than with fish oil. Spray to be applied at different periods in the development of the new buds. The repellent properties of this spray were also to be considered.

June 17, 1931 - Second section of area sprayed.

June 30, 1931 - Third section of area sprayed.

July 13, 1931 - Final examination of plots based upon new growth tips taken from sprayed and unsprayed trees.

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERAGE

Plot #7A - Newton Creek

Data from 2 Trees Sprayed June 11, 1931

Degree of Injury		Degree of coverage trees treated: Good Tips	Fair Tips	Poor 608 Tips	Unsprayed Trees (4) 1232 Tips
None	No. of Tips			495	677
	% of Tips			81.4	55.0
0-30%	No. of Tips			46	180
	% of Tips			7.6	14.6
30-60%	No. of Tips			34	96
	% of Tips			5.6	7.8
60-90%	No. of Tips			12	40
	% of Tips			2.0	3.2
100%	No. of Tips			21	239
	% of Tips			3.4	19.4
Average Injury				8.6%	27.5%

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERAGE

Plot #7B - Newton Creek

Data from 2 Trees Sprayed on June 17, 1931

Degree of Injury		Degree of coverage trees treated: Good (350 Tips)	Fair (140 Tips)	Poor (161 Tips)	Total (Tips 651)	Unsprayed Trees (4) (1232 Tips)
None	No. of Tips	306	115	92	513	677
	% of Tips	87.4	82.1	57.2	78.8	55.0
0-30%	No. of Tips	9	9	21	39	180
	% of Tips	2.6	6.4	13.0	6.0	14.6
30-60%	No. of Tips	13	6	13	32	96
	% of Tips	3.7	4.3	8.1	4.9	7.8
60-90%	No. of Tips	5	1	1	7	40
	% of Tips	1.4	.7	.6	1.1	3.2
100%	No. of Tips	17	9	34	60	239
	% of Tips	4.9	6.4	21.1	9.2	19.4
Average Injury		8.0%	9.9%	27.2%	16.4%	27.5%

Plot #7C - Newton Creek

Data from 2 Trees Sprayed June 30, 1931

Degree of Injury		Degree of coverage trees treated: Good (336 Tips)	Fair (78 Tips)	Poor (201 Tips)	Total (Tips 615)	Unsprayed Trees (4) (1232 Tips)
None	No. of Tips	252	63	155	470	677
	% of Tips	75.0	80.7	77.1	76.5	55.0
0-30%	No. of Tips	16	6	18	40	180
	% of Tips	4.8	7.7	8.9	6.5	14.6
30-60%	No. of Tips	22	2	10	34	96
	% of Tips	6.5	2.6	5.0	5.5	7.8
60-90%	No. of Tips	12	0	1	13	40
	% of Tips	3.6	.0	.5	2.1	3.2
100%	No. of Tips	34	7	17	58	239
	% of Tips	10.1	9.0	8.5	9.4	19.4
Average Injury		16.5%	11.3%	12.4%	14.5%	27.5%

With the first treatment a very poor coverage was secured, which was perhaps due to the fact that the new growth was not fully out. However, regardless of this poor coverage, a reduction of 68.7% in the defoliation of the treated trees was secured. The second application shows a fair coverage with a reduction of 40.3% in the defoliation, while the third application resulted in a fair coverage with a reduction of 47.3%. These data relative to the difference in defoliation for the three sections of this plot are not consistent. This is no doubt due to existing differences in the trees selected for examination as it is extremely difficult to select trees all with the same intensity of infestation. Though these data cannot be regarded as final, it would seem that the results secured from this treatment are a trifle more favorable than with most of the other formulae used. For the three sections of this plot the percentage of reduction was as follows: A - 68.7, B - 40.3, and C - 47.3. When examined in August treated trees appeared in better condition than those unsprayed.

Experiment B-11

Spray Plot #8
Newton Creek, North

June 16, 1931 - Budworm infestation light. An examination of 1200 new growth tips from 4 trees showed 33 larvae, or .028 larvae per tip.

June 16, 1931 - Area sprayed.

Formulae - Lead-arsenate 36#, fish oil 5 quarts, Kayso 25#, water 600 gallons.

Foliage - Buds open. Foliage nearly all out.

Weather - Hot, no wind.

Amount of spray used - 600 gallons.

The purpose of this experiment was to test the spreading properties of Kayso, a commercial spreader, in the hope of securing a better coverage at the base of the needles where the larvae feed. It was thought that this spray might act as a repellent to subsequent oviposition.

July 10, 1931 - Final examination based upon new growth tips from 4 sprayed and 4 unsprayed trees.

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERAGE

Degree of Injury		Degree of coverage trees treated: Good (116 Tips)	Fair (285 Tips)	Poor (834 Tips)	Total (Tips 1235)	Unsprayed Trees (1206 Tips)
None	No. of Tips:	112	248	726	1086	1017
	% of Tips:	96.6	86.9	87.0	87.9	84.3
0-30%	No. of Tips:	4	25	47	76	80
	% of Tips:	3.4	8.8	5.6	6.2	6.6
30-60%	No. of Tips:		5	32	37	60
	% of Tips:		1.8	3.9	3.0	5.0
60-90%	No. of Tips:		4	11	15	14
	% of Tips:		1.4	1.3	1.2	1.2
100%	No. of Tips:		3	18	21	35
	% of Tips:		1.1	2.2	1.7	2.9
Average Injury		0.5%	4.2%	5.7%	4.9%	7.0%

The coverage secured from this treatment was recorded as "Poor" which was no better than that secured with just lead-arsenate and fish oil. However, the difference in the defoliation between the treated and untreated trees amounted to 30%. Again the effectiveness of this treatment is difficult to measure because of the light infestation encountered. No difference between the defoliation of treated and untreated trees could be observed during a visual examination of this area on August 6.

Experiment B-13

Spray Plot #9
Cliff Creek

June 16, 1931 - Budworm infestation light. An examination of 1200 new growth tips from 4 trees showed 145 larvae, or .083 per tip.

June 23, 1931 - Plot sprayed.
Formulae - Lead-arsenate 24#, molasses 4 gal., water 400 gal.
Foliage - Buds all opened. Foliage nearly all out.
Weather - Clear, warm, windy, with showers.
Amount of spray used - 400 gallons.
Purpose of this experiment was to test the properties of black strap molasses as a combination sticker and spreader, in the hopes that the molasses would make the arsenate more attractive to the feeding larvae.

July 15, 1931 - Final examination of this plot based on defoliation of new growth tips from 4 sprayed and 4 unsprayed trees.

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERAGE

Degree of Injury		Degree of coverage trees treated: Good :208 Tips	Fair :226 Tips	Poor :844 Tips	Total :Tips 1278	Unsprayed Trees 1226 Tips
None	No. of Tips:	181	191	651	1023	869
	% of Tips:	87.0	84.5	77.2	80.0	70.9
0-30%	No. of Tips:	10	14	83	107	96
	% of Tips:	4.8	6.2	9.8	8.4	7.8
30-60%	No. of Tips:	12	11	44	67	81
	% of Tips:	5.8	4.9	5.2	5.3	6.6
60-90%	No. of Tips:	3	7	27	37	56
	% of Tips:	1.4	3.1	3.2	2.9	4.6
100%	No. of Tips:	2	3	39	44	124
	% of Tips:	1.0	1.3	4.6	3.4	10.1
Average Injury		5.4%	6.8%	10.8%	9.2%	17.7%

As a result of this treatment a coverage rated as "Poor plus" was secured. However, based upon the defoliation of the untreated trees, a reduction of 48% was secured. It is possible that the use of some such attractant in a stomach poison spray may result in better results than just the ordinary lead-arsenate fish oil sprays. From a visual examination of this area on August 6, it was evident that the treated trees appeared in better condition than the untreated ones used as checks.

Experiment B-4

Spray Plot #10
Window Rock Camp

June 12, 1931 - Budworm infestation light. An examination of 450 new growth tips from 3 trees showed 79 larvae, or .175 per tip.

June 17, 1931 - Area sprayed.
Formulae - Lead-arsenate 36#, water 600 gallons.
Foliage - Buds opened, foliage out.
Weather - Clear, warm, windy.
Amount of spray used - 1600 gallons.
Purpose of this experiment was to check the use of lead-arsenate alone to determine the actual benefits of stickers and spreaders.

July 16, 1931 - Final examination based upon new growth tips taken from 4 treated and 4 untreated trees.

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERAGE

Degree of Injury		Degree of coverage trees treated: Good 54 Tips	Fair 172 Tips	Poor 1010 Tips	Total Tips 1236	Unsprayed Trees 1224 Tips
None	No. of Tips:	50	156	741	947	817
	% of Tips:	926	90.7	73.4	76.6	66.8
0-30%	No. of Tips:	3	11	119	133	119
	% of Tips:	5.6	6.4	11.8	10.7	9.7
30-60%	No. of Tips:		4	69	73	87
	% of Tips:		2.3	6.8	5.9	7.1
60-90%	No. of Tips:			34	34	94
	% of Tips:			3.4	2.8	7.7
100%	No. of Tips:	1	1	47	49	107
	% of Tips:	1.8	.6	4.6	4.0	8.7
Average Injury		2.7%	2.6%	12.0%	10.3%	19.2%

As a result of this treatment a "Poor plus" coverage existed at the time of this examination. However, immediately following the application of spray on June 17 an excellent coverage existed, which was apparently washed off by subsequent rain, due to the lack of stickers. From this treatment a 46% reduction was secured, which would seem to be as good as that which followed the use of stickers and spreaders. Visual examination of this plot on August 6 indicated that the treated trees looked fairly good and better than the untreated ones used as checks.

Experiment B-12

Spray Plot #11
Elephant Head

June 17, 1931 - Budworm infestation light. An examination of 1200 new growth tips from 4 trees showed but 61 larvae, or .051 per tip.

June 18, 1931 - Area sprayed.
Formulae - Barium fluosilicate 10#, fish oil 5 qts., water 600 gal.
Foliage - Opened.
Weather - Clear, warm and heavy winds.
Amount of spray used - 600 gallons.
Purpose of this experiment was to test Barium fluosilicate as a stomach poison.

July 16, 1931 - Final examination based upon examination of defoliation of new growth tips from sprayed and unsprayed trees.

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERAGE

Degree of Injury		Degree of coverage trees treated: Good 7 Tips	Fair 1 Tip	Poor 1214 Tips	Total Tips 1222	Unsprayed Trees 1213 Tips
None	No. of Tips:	7	1	1101	1109	1083
	% of Tips:			90.7	90.8	89.2
0-30%	No. of Tips:			57	57	62
	% of Tips:			4.7	4.6	5.1
30-60%	No. of Tips:			30	30	25
	% of Tips:			2.5	2.5	2.1
60-90%	No. of Tips:			6	6	25
	% of Tips:			.5	.5	2.1
100%	No. of Tips:			20	20	18
	% of Tips:			1.6	1.6	1.5
Average Injury		0.00%	0.00%	38.3	38.1%	47.2%

From this treatment a "Poor" coverage resulted with only a 19% reduction in the infestation, which is practically negligible. Visual examination of this plot on August 6 indicated no difference between the treated and untreated trees.

June 3, 1931 - Budworm infestation light. An examination of 300 new growth tips from 2 trees showed 29 larvae, or .097 per tip.

June 11, 1931 - Plot 12A sprayed (early).
Formulae - Lead-arsenate 2#, linseed oil 3 qts., water 400 gal.
Foliage - Fully out.
Weather - Cloudy, cool, windy, showers on 12.

June 23, 1931 - Plot 12B sprayed (medium).
Weather - Clear, warm, windy, showers.

June 30, 1931 - Plot 12C sprayed (late).
Weather - Clear, warm, some rain.
Total amount of spray used - 1200 gallons (400 gallons for each plot)

Purpose of this experiment was to test the effectiveness of linseed oil as a spreader and sticker, applied at different stages in the development of the new growth.

July 17, 1931 - Final examination based upon defoliation of new growth tips from sprayed and unsprayed trees.

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERAGE

Plot 12A - Chimney Rock

Data from 3 Trees Sprayed June 11, 1931

Degree of Injury		Degree of coverage trees treated: Good (46 Tips)	Fair (70 Tips)	Poor (804 Tips)	Total (Tips 920)	Unsprayed Trees (4) (1323 Tips)
None	No. of Tips:	46	65	603	714	619
	% of Tips:		92.9	75.0	77.6	46.9
0-30%	No. of Tips:		3	62	65	114
	% of Tips:		4.3	7.7	7.1	8.6
30-60%	No. of Tips:		2	55	57	114
	% of Tips:		2.8	6.8	6.2	8.6
60-90%	No. of Tips:			26	26	117
	% of Tips:			3.3	2.8	8.8
100%	No. of Tips:			58	58	359
	% of Tips:			7.2	6.3	27.1
Average Injury		0.00%	1.9%	13.8%	12.3%	38.9%

Experiment B-2 — Chimney Rock

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERAGE

Plot 12B - Chimney Rock

Data from 2 Trees Sprayed June 23, 1931

Degree of Injury		Degree of coverage trees treated: Good (138 Tips)	Fair (91 Tips)	Poor (400 Tips)	Total (Tips 629)	Unsprayed Trees (4) (1323 Tips)
None	No. of Tips:	91	60	248	399	619
	% of Tips:	66.0	65.9	62.0	63.4	46.9
0-30%	No. of Tips:	9	19	44	72	114
	% of Tips:	6.5	20.9	11.0	11.4	8.6
30-60%	No. of Tips:	10	2	47	59	114
	% of Tips:	7.2	2.2	11.7	9.4	8.6
60-90%	No. of Tips:	11	5	26	42	117
	% of Tips:	8.0	5.5	6.5	6.7	8.8
100%	No. of Tips:	17	5	35	57	359
	% of Tips:	12.3	5.5	8.8	9.1	27.1
Average Injury		22.5%	13.7%	20.6%	20.0%	38.9%

Plot 12C - Chimney Rock

Data from 2 Trees Sprayed June 30, 1931

Degree of Injury		Degree of coverage trees treated: Good (478 Tips)	Fair (97 Tips)	Poor (41 Tips)	Total (Tips 616)	Unsprayed Trees (4) (1323 Tips)
None	No. of Tips:	398	77	35	510	619
	% of Tips:	83.3	79.4	85.3	81.1	46.9
0-30%	No. of Tips:	31	6	3	40	114
	% of Tips:	6.5	6.2	7.3	6.4	8.6
30-60%	No. of Tips:	17	3	2	22	114
	% of Tips:	3.6	3.1	4.9	3.5	8.6
60-90%	No. of Tips:	17	7		24	117
	% of Tips:	3.5	7.2		3.8	8.8
100%	No. of Tips:	15	4	1	20	359
	% of Tips:	3.1	4.1	2.4	3.2	27.1
Average Injury		8.4%	11.9%	5.7%	8.5%	38.9%

From the early treatment a "Poor plus" coverage was secured with a reduction in the defoliation amounting to 68%. With the second application on the "B" section of this plot the coverage remained about the same with a reduction of defoliation amounting to only 48%. With the third application on the "C" section of the plot, a good coverage was secured, which resulted in a reduced defoliation of 78%. It is very apparent that the late spray, applied under conditions encountered on June 30, gave rather satisfactory results. Why the second application on section "B" did not show as great a reduction as secured on section "A" was no doubt due to weather conditions, or error in the selection of trees for examination.

Experiment B-5

Spray Plot #13
Chimney Rock, South & West

June 17, 1931 - Budworm infestation light. Examination of 1200 new growth tips from 4 trees showed 133 larvae, or .111 per tip.

June 23, 1931 - Area sprayed.
Formulae - Lead-arsenate 24#, fish oil 2½ qts., pine oil 1/2 qt. water 400 gallons.
Foliage - Fully opened.
Weather - Clear, warm, windy, some showers.
Amount of spray used - 400 gallons.
Purpose of this experiment was to determine if through the addition of pine oil the standard stomach poison would not be made more attractive to the feeding larvae.

July 17, 1931 - Final examination based upon defoliation of new growth tips from sprayed and unsprayed trees.

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERAGE

Degree of Injury		Degree of coverage trees treated: Good (125 Tips)	Fair (218 Tips)	Poor (286 Tips)	Total (Tips 629)	Unsprayed Trees (Tips 639)
None	No. of Tips:	109	190	224	523	373
	% of Tips:	87.2	87.2	78.3	83.2	58.4
0-30%	No. of Tips:	5	15	30	50	68
	% of Tips:	4.0	6.9	10.5	7.9	10.6
30-60%	No. of Tips:	11	7	23	41	35
	% of Tips:	8.8	3.2	8.0	6.5	5.5
60-90%	No. of Tips:		4	6	10	34
	% of Tips:		1.8	2.1	1.6	5.3
100%	No. of Tips:		2	3	5	129
	% of Tips:		.9	1.1	.8	20.2
Average Injury		4.6%	4.8%	7.8%	6.1%	28.2%

From this treatment a "Fair" coverage was secured, with a reduced defoliation amounting to 78% which would appear very favorable, though no better than that secured with just linseed oil. It would seem that perhaps this experiment offers some possibilities, and should receive further consideration.

Experiment B-6

Spray Plot #14
Chimney Rock, South & West

June 17, 1931 - Budworm infestation light. An examination of 1200 new growth tips from 4 trees showed 133 larvae, or .111 per tip.

June 23, 1931 - Area sprayed.
Formulae - Lead-arsenate 24#, pine oil 3 qts., water 400 gallons.
Foliage - Fully opened.
Weather - Clear, warm, wind and showers.
Amount of spray used - 400 gallons.
Purpose of experiment was to determine if pine oil used in lieu of fish oil would be less objectionable to the feeding larvae. Possibility of the spray acting as a repellent to oviposition also to be considered.

July 17, 1931 - Final examination of plot based upon the defoliation of new growth tips of sprayed and unsprayed trees.

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERAGE

Degree of Injury		Degree of coverage trees treated: Good (292 Tips)	Fair (17 Tips)	Poor (313 Tips)	Total (Tips 622)	Unsprayed Trees (639 Tips)
None	No. of Tips:	234	17	256	507	373
	% of Tips:	80.1	100.0	81.8	81.5	58.4
0-30%	No. of Tips:	9		35	44	68
	% of Tips:	3.1		11.2	7.1	10.6
30-60%	No. of Tips:	17		11	28	35
	% of Tips:	5.8		3.5	4.5	5.5
60-90%	No. of Tips:	14		4	18	34
	% of Tips:	4.8		1.3	2.9	5.3
100%	No. of Tips:	18		7	25	129
	% of Tips:	6.2		2.2	4.0	20.2
Average Injury		12.8%	0.0%	6.5%	9.3%	28.2%

As a result of this treatment a fair coverage resulted with a reduction in the defoliation of 67%. Though this reduction would seem to be satisfactory, it cannot be considered as being more effective than some of the other formulaes used.

Experiment B-9

Spray Plot #15
Goff Creek (South)

June 17, 1931 - Budworm infestation light. Examination of 1200 new growth tips showed 197 larvae, or .164 per tip.

June 23, 1931 - Area sprayed.
Formulae 15A - Lead-arsenate 24#, Volck 4 gal., water 400 gal.
Formulae 15B - Lead-arsenate 24#, Volck 16 gal., water 400 gal.
Foliage - Fully opened.
Weather - Clear, warm, windy, some rain.
Amount of spray used - 800 gallons.

Purpose of this experiment was to test the two strengths of Volck as a sticker, and as a possible stomach poison and contact spray.

July 28, 1931 - Final examination based upon defoliation of new growth tips of sprayed and unsprayed trees.

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERAGE

Plot #15A - Goff Creek (South)

Data from 4 Trees Sprayed June 23, 1931.

Degree of Injury		Degree of coverage trees treated: Good (486 Tips)	Fair (157 Tips)	Poor (645 Tips)	Total (Tips 1288)	Unsprayed Trees (4) 1263 Tips
None	No. of Tips:	416	122	252	790	481
	% of Tips:	85.6	77.8	39.1	61.3	38.1
0-30%	No. of Tips:	19	16	144	179	162
	% of Tips:	3.9	10.2	22.3	13.9	12.9
30-60%	No. of Tips:	35	9	78	122	158
	% of Tips:	7.2	5.7	12.1	9.5	12.5
60-90%	No. of Tips:	8	4	66	78	161
	% of Tips:	1.6	2.5	10.2	6.1	12.7
100%	No. of Tips:	8	6	105	119	301
	% of Tips:	1.7	3.8	16.3	9.2	23.8
Average Injury		6.7%	9.8%	32.7%	20.1%	40.9%

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERAGE

Data from 4 Trees Sprayed June 23, 1931

Degree of Injury		Degree of coverage trees treated: Good (498 Tips)	Fair (354 Tips)	Poor (435 Tips)	Total (Tips 1287)	Unsprayed Trees (4) (1263 Tips)
None	No. of Tips:	414	278	271	963	481
	% of Tips:	83.2	78.5	62.3	74.9	38.1
0-30%	No. of Tips:	42	36	62	140	162
	% of Tips:	8.4	10.2	14.2	10.9	12.9
30-60%	No. of Tips:	26	22	35	83	158
	% of Tips:	5.2	6.2	8.1	6.4	12.5
60-90%	No. of Tips:	7	8	38	53	161
	% of Tips:	1.4	2.3	8.7	4.1	12.7
100%	No. of Tips:	9	10	29	48	301
	% of Tips:	1.8	2.8	6.7	3.7	23.8
Average Injury		6.5%	8.8%	19.0%	11.4%	40.9%

With the first formulae, where but 4 gallons of Volck was used, a fair coverage followed, and a reduction in the defoliation amounting to 50.8% secured. With the stronger solution, where 16 gallons of Volck were used, a reduction of 72% was secured with the same coverage. It would seem that the heavy dosage of Volck, which made a 4% solution, had some beneficial effects as a contact spray.

Experiment B-7

Spray Plot #16
Draw 3/4 Mile West Chimney Rock

June 18, 1931 - Budworm infestation light. Examination of 1200 new growth tips from 4 trees showed 92 larvae, or .077 per tip.

June 18, 1931 - Plot 16A sprayed.
Formulae - Ortho zinc arsenate 12#, water 400 gallons.
Foliage - Fully out.
Weather - Clear, warm, some wind.
Amount of spray used - 400 gallons.

June 28, 1931 - Plot 16B sprayed.
Formulae - Same.
Foliage - Same.
Weather - Clear, warm.
Amount of spray used - 400 gallons.

Purpose of this experiment was to test the value of ortho zinc arsenate as a stomach poison with no sticker or spreader, when applied at different periods in the season.

July 27, 1931 - Final examination made from defoliation on new growth tips on sprayed and unsprayed trees.

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERAGE

Plot #16A

Data from 4 Trees Sprayed June 18, 1931

Degree of Injury		Degree of coverage trees treated: Good 13 Tips	Fair 85 Tips	Poor 1137 Tips	Total Tips 1235	Unsprayed Trees (4) 1221 Tips
None	No. of Tips:	12	79	1012	1103	1039
	% of Tips:	92.3	92.9	89.0	89.3	85.1
0-30%	No. of Tips:		6	60	66	76
	% of Tips:		7.1	5.3	5.3	6.2
30-60%	No. of Tips:			37	37	52
	% of Tips:			3.2	3.0	4.3
60-90%	No. of Tips:			17	17	37
	% of Tips:			1.5	1.4	3.0
100%	No. of Tips:	1		11	12	17
	% of Tips:	7.7		1.0	1.0	1.4
Average Injury		7.7%	1.1%	4.3%	4.2%	6.5%

Experiment B-7

Spray Plot #16
Draw 3/4 Mile West Chimney Rock

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERAGE

Plot #16B

Data from 4 Trees Sprayed June 18, 1931

Degree of Injury		Degree of coverage trees treated: Good 421 Tips	Fair 347 Tips	Poor 489 Tips	Total Tips 1257	Unsprayed Trees (4) 1221 Tips
None	No. of Tips:	364	295	439	1098	1039
	% of Tips:	86.4	85.0	89.8	87.4	85.1
0-30%	No. of Tips:	22	23	25	70	76
	% of Tips:	5.2	6.6	5.1	5.6	6.2
30-60%	No. of Tips:	18	16	15	49	52
	% of Tips:	4.3	4.6	3.1	3.9	4.3
60-90%	No. of Tips:	7	9	6	22	37
	% of Tips:	1.7	2.6	1.2	1.7	3.0
100%	No. of Tips:	10	4	4	18	17
	% of Tips:	2.4	1.2	.8	1.4	1.4
Average Injury		6.3%	6.2%	3.9%	5.3%	6.5%

From the early treatment on Plot 16A a poor coverage was secured, which resulted in a reduction of 35% in the very light infestation. The late treatment on Plot 16B also produced a poor coverage with a reduction in the defoliation of 18%. It is difficult to judge the effects of such sprays when applied to the light infestations encountered; however, it would seem that this material is not as effective as some of the other sprays used.

Experiment E-5

Spray Plot #17
Eagle Creek Camp Ground

June 19, 1931 - Budworm infestation light. Examination of 1200 new growth tips from 4 trees showed 100 larvae, or .085 per tip.

June 22, 1931 - Area sprayed.
Formulae - Lead-arsenate 24#, fish oil 2½ quarts, pine oil 1/2 quart, water 400 gallons.
Foliage - Buds fully out.
Weather - Clear, warm and slight wind.
Amount of spray used - 400 gallons.

The purpose of this experiment was to test the possibilities of pine oil making the spray more attractive as a food to the feeding larvae. The possibility of this spray acting as a repellent to oviposition was also to be considered.

July 30, 1931 - Final examination based upon defoliation of new growth tips from treated and untreated trees.

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERAGE

Degree of Injury		Degree of coverage trees treated: Good 5 Tips	Fair 128 Tips	Poor 498 Tips	Total Tips 631	Unsprayed Trees 605 Tips
None	No. of Tips:	5	113	458	576	531
	% of Tips:		88.3	91.9	91.3	87.8
0-30%	No. of Tips:		12	19	31	23
	% of Tips:		9.4	3.9	4.9	3.8
30-60%	No. of Tips:		3	6	9	26
	% of Tips:		2.3	1.2	1.4	4.3
60-90%	No. of Tips:			10	10	11
	% of Tips:			2.0	1.6	1.8
100%	No. of Tips:			5	5	14
	% of Tips:			1.0	.8	2.3
Average Injury		0.0%	2.5%	3.6%	3.4%	6.2%

This treatment resulted in a "Poor plus" coverage, and a reduction in a very light infestation of 45%. However, to attempt to measure the results of a spray when applied to such a light infestation is indeed very questionable.

Experiment B-6

Spray Plot #18
Eagle Creek Camp Ground

June 19, 1931 - Budworm infestation light. Examination of 1200 new growth tips showed 102 larvae, or .085 per tip.

June 22, 1931 - Trees sprayed.
Formulae - Lead-arsenate 24#, pine oil 3 qts., water 400 gal.
Foliage - Fully out.
Weather - Clear, warm, slight showers.
Amount of spray used - 1,000 gallons.

The purpose of the experiment is to test the possibility of pine oil as a spreader and sticker relative to it being more effective than fish oil.

July 30, 1931 - Final examination based upon the difference in defoliation of new growth tips of treated and untreated trees.

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERAGE

Degree of Injury		Degree of coverage trees treated: Good (540 Tips)	Fair (236 Tips)	Poor (185 Tips)	Total (Tips 961)	Unsprayed Trees (605 Tips)
none	No. of Tips:	394	153	108	655	531
	% of Tips:	73.0	64.8	58.4	68.1	87.8
0-30%	No. of Tips:	59	34	37	130	23
	% of Tips:	10.9	14.4	20.0	13.5	3.8
30-60%	No. of Tips:	32	17	16	65	26
	% of Tips:	5.9	7.2	8.6	6.8	4.3
60-90%	No. of Tips:	33	20	9	62	11
	% of Tips:	6.1	8.5	4.9	6.5	1.8
100%	No. of Tips:	22	12	15	49	14
	% of Tips:	4.1	5.1	8.1	5.1	2.3
Average Injury		13.0%	16.8%	18.6%	15.0%	6.2%

With this treatment a "Fair plus" coverage was secured; however, the treated trees showed an increased defoliation of 141% over the untreated ones. If the treated trees were more severely defoliated, and this difference in the data was not the result of poorly selected trees for examination, it is possible that this spray acted as a repellent to parasitic or predacious insects as it is doubtful if larvae would be attracted to trees treated in this manner. Of course, this difference in defoliation, when dealing with such a light infestation, could be explained through the selection of trees for check examination.

Experiment B-8

Spray Plot #19
Blackwater Corral

June 26, 1931 - Budworm infestation light.

June 26, 1931 - Area sprayed.
Formulae - Calcium arsenate 36#, fish oil 5 qts., water 600 gal.
Foliage - Fully out.
Weather - Clear, warm, slight breeze
Amount of spray used - 600 gallons.

Purpose of this experiment was to compare the effectiveness of calcium arsenate and lead arsenate.

August 1, 1931 - Final examination made of new growth tips from treated and untreated trees.

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERAGE

Degree of Injury		Degree of coverage trees treated: Good 433 Tips	Fair 267 Tips	Poor 885 Tips	Total Tips 1585	Unsprayed Trees 1542 Tips
None	No. of Tips:	408	237	801	1446	1333
	% of Tips:	94.3	88.8	90.5	91.2	86.4
0-30%	No. of Tips:	11	14	43	68	89
	% of Tips:	2.5	5.2	4.9	4.3	5.8
30-60%	No. of Tips:	10	10	16	36	60
	% of Tips:	2.3	3.7	1.8	2.3	3.9
60-90%	No. of Tips:	3	5	12	20	35
	% of Tips:	.7	1.9	1.3	1.3	2.3
100%	No. of Tips:	1	1	13	15	25
	% of Tips:	.2	.4	1.5	.9	1.6
Average Injury		.2%	4.3%	4.0%	3.6%	5.9%

With this treatment a "Fair" coverage was secured with a reduction in the defoliation amounting to 39%. Again we have a light infestation upon which to base results, which is difficult.

Experiment B-3

Spray Plot #20
Holm Lodge

June 15, 1931 - Budworm infestation light.

June 15, 1931 - Area sprayed.
Formulae - Lead-arsenate 36#, fish oil 5 quarts, skimmed milk 6 gal., water 600 gallons.
Foliage - Fully out.
Weather - Clear, warm, slight wind.
Amount of spray used - 600 gallons.

Purpose of this experiment was to determine if a better coverage near the base of the new needles could be secured with the addition of skimmed milk to the lead-arsenate spray.

July 29, 1931 - Final examination based upon new growth tips from treated and untreated trees.

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERAGE

Degree of Injury		Degree of coverage trees treated: Good (249 Tips)	Fair (240 Tips)	Poor (786 Tips)	Total (Tips 1275)	Unsprayed Trees (1221 Tips)
None	No. of Tips:	225	167	522	914	1067
	% of Tips:	90.4	69.6	66.4	71.7	87.4
0-30%	No. of Tips:	8	26	105	139	55
	% of Tips:	3.2	10.8	13.4	10.9	4.5
30-60%	No. of Tips:	12	26	73	111	49
	% of Tips:	4.8	10.8	9.3	8.7	4.0
60-90%	No. of Tips:	3	15	52	70	24
	% of Tips:	1.2	6.3	6.6	5.5	2.0
100%	No. of Tips:	1	6	34	41	26
	% of Tips:	.4	2.5	4.3	3.2	2.1
Average Injury		4.0%	13.6%	15.5%	12.9%	6.1%

With this formulae, though a "Fair" coverage followed, it was no better than that secured without the skimmed milk. The defoliation on the treated trees was 111% more severe than on those used as checks. These data cannot be explained except that the spraying was not responsible for this increased defoliation, and that with the light infestation a slight error in the selection of trees for examination could have been responsible.

Experiment C-1

Spray Plots 21-22
Holm Lodge

Though the possibility of destroying the egg masses of the spruce budworm through the application of an ovicide was tested in 1930, it was thought well to make additional attempts during the 1931 season. The difficulty of any such method of control lies in the fact that oviposition is extended over a longer period than that required for incubation, and the first eggs being hatched before the last are deposited. This would necessitate more than one application of spray if thorough control was to be effective. However, it might be possible to apply one spray at a time when sufficient eggs would be destroyed to minimize the resulting damage. Though the tests conducted in 1930 and again in 1931 show some results, it seemed difficult to secure a very high mortality of the egg masses, which is no doubt accounted for by a lack of coverage or contact. The results of the 1931 experiments are shown in the following tables.

Plot 21

July 24, 1931 - Plot sprayed.
Formulae - Lead-arsenate 8#, Volck 12 gallons, water 400 gal.
3% Volck solution.

Date of Egg Mass Collection	Number of Egg Masses Collected	Number Egg Masses Hatched	Per cent of Egg Masses Hatched	Reduction in the Infestation
July 27, 1931	70	July 27-August 15 11 Egg Masses Hatched	15.7%	84.3%
July 31, 1931	162	July 31-August 15 18 Egg Masses Hatched	11.1%	88.9%
Total	232	29	12.5%	87.5%
Reduction Natural Causes 23.7%	55			
Living Egg Masses	177	29	16.4%	83.6%

Plot 22

July 24, 1931 - Plot sprayed.
Formulae- Lead-arsenate 12#, nicotine sulphate 2 qts., water 400 gallons.

Date of Egg Mass Collection	Number of Egg Masses Collected	Number of Egg Masses Hatched	Per cent of Egg Masses Hatched	Reduction in the Infestation
July 25, 1931	59	30	51%	49%
July 31, 1931	57	45	79%	21%
Total	116	75	64.6%	35.4%
Reduction Natural Causes 23.7%	27			
Living Egg Masses	89	75	84.2%	15.8%

Unsprayed Check Plot

Date of Egg Mass Collection	Number of Egg Masses Collected	Number of Egg Masses Hatched	Per cent of Egg Masses Hatched	Natural Reduction in Infestation
July 25, 1931	69	50	72%	28%
July 31, 1931	24	21	87%	13%
Total	93	71	76.3%	23.7%

As a result of these tests it would seem that rather fair results were secured with the 3% Volck solution. Though 87.5% of the egg masses were destroyed as a result of this treatment, in actual practice this figure would be reduced somewhat by the natural mortality of the eggs as shown in the check plot. From these data it will be seen that a natural mortality in the egg masses of 23.7% exists. When this figure is applied to the results of the two treatments, the per cent of reduction is reduced from 87.5% to 83.6% for the Volck, and from 35.4% to 15.8% for the nicotine sulphate.

As a further check upon these results, an area treated with Volck during the 1930 operation was examined to see if any effects of the ovicide could be observed in 1931. A number of trees were examined and a comparison made between the sprayed and unsprayed trees on the basis of injured 1931 new growth tips. The sprayed trees showed 42 per cent of the tips uninjured as compared to 36 per cent on the check or unsprayed trees. However, this slight difference cannot be taken as a direct measurement of the value of an ovicide, as this plot was sprayed rather late in the season, and other complicating factors must be taken into its consideration.

SUMMARY OF EXPERIMENTAL SPRAYING

Plot No.	Experiment No.	Formulae	Defoliation of Treated Trees	Defoliation of Untreated Trees	Reduction in Defoliation
4	B-1 a	L.A. 24#, F.O. 3 qts. H20 400 gal.	19.1%	31.4%	39%
	b		12.3%	31.4%	60%
	c		3.0%	31.4%	90%
12	B-2 a	L.A. 24#, Linseed Oil 3 qts. H20 400 gallons	12.3%	38.9%	68%
	b		20.0%	38.9%	48%
	c		8.5%	38.9%	78%
13	B-5	L.A. 24#, Fish Oil 2½ qts. Pine Oil ½ qt., Water 400 gal.	6.1%	28.2%	78%
15	B-9 a	L.A. 24#, Volck 4 gal. H20 400 Gal	20.1%	40.9%	51%
	b	L.A. 24#, Volck 16 gal H20 400 Gal	11.4%	40.9%	72%
7	B-2 a	L.A. 24#, Linseed Oil 3 qts. H20 - 400 gallons	8.6%	27.5%	68%
	b		16.4%	27.5%	40%
	c		14.5%	27.5%	47.2%
14	B-6	L.A. 24#, Pine Oil 3 qts. H20 - 400 gallons	9.3%	28.2%	67%
5	B-3	L.A. 24#, Fish Oil 3 qts. Skim Milk 3 gal. H20 - 400 gal.	5. %	9.9%	49%
9	B-13	L.A. 24#, Molasses 4 gallons H20 - 400 gallons	9.2%	17.7%	48%
	B-4	L.A. 36#, H20 - 600 gallons	10.3%	19.2%	46%
17	B-5	L.A. 24#, Fish Oil 2½ qts. Pine Oil ½ qt., H20 - 400 gallons	3.4%	6.2%	45%
19	B-8	Calcium Arsenate 36# Fish Oil 5 qts., H20 - 600 gallons	3.6%	5.9%	39%
16	B-7 a	Ortho Zinc Arsenate 12#	4.2%	6.5%	35%
	b	H20 - 400 gallons	5.3%	6.5%	18%
3	B-1 a	L.A. 24#, Fish Oil 3 qts. H20 - 400 gallons	11.4%	11.9%	4%
	b		8.1%	11.9%	32%
	c		12.6%	11.9%	+ 5%

SUMMARY OF EXPERIMENTAL SPRAYING
(CONT.)

Plot No.	Experiment No.	Formulae	Defoliation of Treated Trees	Defoliation of Untreated Trees	Reduction in Defoliation
8	B-11	L.A. 36#, Fish Oil 5 qts. Kayso 25#, H20 - 600 gallons	4.9%	7. %	30%
11	B-12	Barium fluosilicate 10# Fish Oil 5 qts., H20 - 600 gallons	38.1%	47.2%	19%
1	A-1	L.A. 36#, Fish Oil 5 qts. H20 - 600 gallons	33.4%	34.6%	3%
6	B-10	L.A. 36#, Fish Oil 5 qts. Nic. Sulp. 4 qts., H20 - 600 gal.	4.9%	5.0%	2%
2	A-2	L.A. 36#, Fish Oil 5 qts. Nic. Sulp. 4 qts., H20 - 600 gal.	7.3%	5.4%	+35%
20	B-3	L.A. 36#, Fish Oil 5 qts. Skimmed Milk 6 gal., H20 - 600 gal	12.9%	6.1%	+111%
18	B-6	L.A. 24#, Pine Oil 3 qts. H20 - 400 gallons	15.0%	6.2%	+141%
			Egg Masses Collected	Egg Masses Hatched	Reduction
21	C-1	L.A. 8#, Volck 12 gallons H20 - 400 gallons	232	29	87.5%
22	C-1	L.A. 12#, Nicotine Sulphate 2 qts. H20 - 400 gallons	116	75	35.4%

From the above summary it would seem that Experiment B-1, Plot 4, was perhaps the most successful, showing the greatest reduction (90%) in defoliation. On the other hand, Experiment B-1, Plot 3, with the same treatment and applied on the same dates, gave very poor results, being 13th in the order of effectiveness. It is difficult to explain why this should have occurred except that on Plot 4 a fairly heavy infestation (31.4% defoliation) was present, while on Plot 3 a much lighter infestation (11.9% defoliation) existed.

The second best result secured was with Experiment B-2, Plot 12, where a reduction in the defoliation of 78.9% was secured. Again Experiment B-2, Plot 7, with the same treatment applied at practically the same time, was not so successful as only a 47.2% reduction was secured in the defoliation. Again this difference in the results of these two treatments, though not as marked as with the two tests of B-1, can only be explained by the difference in the severity of the infestation, as with Plot 12 the untreated defoliation amounted to 38.9% while with Plot 7 it was but 27.5%.

Equal in importance to Experiment B-2, Plot 12, is Experiment B-5, Plot 13, where a reduction in the defoliation of 78% was also secured. Again we have this experiment repeated in Plot 17 where only a reduction of 45% was secured; and again this difference between two similar treatments, applied but one day apart, can best be explained by the difference in the severity of the defoliation, which was 28.2% for Plot 13 and only 6.2% for Plot 17.

Experiment B-9, Plot 15, directed against a heavy infestation of 40.9% defoliation, gave the next best results, with a reduction of 51%

for the light damage of Volck and 72% for the heavy. Next in order of effectiveness was Experiment B-6, Plot 14, where a reduction of 67% was secured. However, the same treatment applied on Plot 18 at practically the same time gave negative results, with an increased defoliation on the treated trees over the untreated of 141%. Again the difference in the severity of the infestation, 28.2% and 6.2%, no doubt contributed to these results; however, the increased defoliation of the treated trees must have been the result of a poor selection of trees for examination.

Experiment B-3, Plot 5, directed against a light defoliation of 9.9%, resulted in a decrease of 49%. Contrary to this result, Experiment B-3, Plot 20, gave negative results with an increased defoliation on the treated trees of 111%. Though a difference in the severity of the infestation existed, it was not sufficient to account for this variation of results, which no doubt lies in the difficulty in selecting check trees representative of actual conditions.

Experiment B-13, Plot 9, with a fairly light infestation gave a 48% reduction.

Experiment B-4, Plot 10, with a slightly heavier infestation, resulted in a reduction of 46%.

Experiment B-8, Plot 19, directed against a very light infestation of 5.9% defoliation, resulted in a reduction in the damage of 39%. However, it is difficult to accurately measure the results of treatment directed against such light infestations. The difference in the defoliation of the treated and untreated trees is so slight that any variation could easily have existed in the trees selected for examination. This difficulty

encountered with light infestations can well be applied against the results secured with the remaining Experiments, B-7 Plot 12, B-11 Plot 8, B-10 Plot 6, and B-6 Plot 18, as one can hardly measure the success of these treatments.

Experiment B-12 Plot 11, directed against a heavy infestation of 47.2% defoliation, only resulted in a reduced damage of 19%.

Experiments A-1 Plot 1, and A-2 Plot 2, gave very poor results though A-1 was directed against a fairly heavy infestation. However, these treatments were applied before the buds had opened in an effort to destroy the larvae before they had entered the buds, which was apparently unsuccessful.

In attempting to analyze these different treatments, it is fully realized that the methods as used to determine their effectiveness, though considered as being the best available, are subject to error. Unfortunately a marked decline occurred in the outbreak during the 1930-1931 season, which made the measurement of defoliation of treated and untreated trees very uncertain. Perhaps some of the treatments which are shown in the report as being productive of poor results would produce to the contrary if directed against heavier infestations.

Far more accurate measurements as to the success of these treatments would have been possible if pre-spraying larvae counts, to determine the severity of the infestation, had been made on the <u>same trees</u> which were later used to measure the per cent of defoliation of sprayed and unsprayed trees. With these data available, a weighted measurement could have been applied to the data secured from the treated trees as well as those used as experiment controls.

The ovicide experiment, C-1, Plots 21 and 22, showed rather satisfactory results. As a result of the Volck treatment (3% solution) only 12½% of the egg masses hatched, showing a reduction of 87.5%. However, from check plots it is shown that there is a natural mortality of the egg masses amounting to 23.7%. When this figure is applied to the results of the Volck treatment, the reduction of 87.5% is reduced to 83.6%. Furthermore, this figure would necessarily be reduced somewhat further by the eggs which hatched prior to the treatment and from subsequent oviposition. However, it is possible that one treatment could be applied at a time when sufficient eggs would be destroyed so that the next season's defoliation would be reduced sufficiently to prevent permanent injury to the trees.

TABLE SHOWING RESULTS OF HAND DUSTING AND SPRAYING EXPERIMENTS
TREES TREATED JUNE 26-27, 1931. EXAMINED AUGUST 29, 1931

Tree	Height	Infestation	Treatment	Formulae	Coverage	Results
1	10'	Medium .46 larvae per new growth tip	Sprayed	Ammonia-valeriate 1 oz. Water 4 gallons	?	28% of foliage destroyed
2	15'	Medium .43 larvae per new growth tip	Sprayed	Nicotine sulphate 1/8 qt: Fish Oil 1/8 qt: Water 4 gallons:	Very good	16% of foliage destroyed
3	15'	Medium .32 larvae per new growth tip	Sprayed	Volck 1 qt.: Fish Oil 1/8 qt: Lead Ars. 1/8# Water 4 gal.	Good	Practically all tips burned by spray.
4	30'	Medium .32 larvae per new growth tip	Dusted	Lead Arsenate	Very good: Could not reach top of tree	10% of foliage destroyed
5	15'	Medium .30 larvae per new growth tip	Dusted	Calcium Arsenate	Poor. Could not reach top of tree	22% of foliage destroyed
6	20'	Medium .28 larvae per new growth tip	Dusted	Lead Arsenate	Very good: Could not reach top of tree	7% of foliage destroyed
7	10'	Medium .28 larvae per new growth tip	Sprayed	Ammonia-valeriate 1 oz.: Lead Ars. 1/8# Fish Oil 1/8 qt: Water 4 gal.	Good	13% of foliage destroyed
8	7'	Light .20 larvae per new growth tip	Sprayed	Nicotine sulphate 1/8 oz: Fish Oil 1/8 qt: Water 4 gal.	Very good	6% of foliage destroyed
9	10'	Light .17 larvae per new growth tip	Sprayed	Ammonia-valeriate 1 oz. Lead Ars. 1/8# Water 4 gal:	Good	7% of foliage destroyed
10	20'	Light .16 larvae per new growth tip	Dusted	Calcium Arsenate	Poor. Could not reach top of tree	4% of foliage destroyed

TABLE SHOWING RESULTS OF HAND DUSTING AND SPRAYING EXPERIMENTS
TREES TREATED JUNE 26-27, 1931, EXAMINED AUGUST 29, 1931
(CONT.)

Tree	Height	Infestation	Treatment	Formulae	Coverage	Results
11	7'	Light .0 larvae per new growth tip	Sprayed	Volck 1 qt. Fish Oil 1/8 qt. Lead Ars. 1/8# Water 4 gal.	Good	Practically all tips burned by spray.
12	20'	--	--	Check Tree	--	9% of foliage destroyed
13	10'	--	--	Check Tree	--	26% of foliage destroyed
14	15'	--	--	Check Tree	--	20% of foliage destroyed

It is rather difficult to measure the result secured from the different sprays and dusts, as at the time the trees were treated no larval counts were taken on the trees which were to be used as checks on controls. Furthermore, as there is so little difference in the injury between the treated and untreated trees, it is even more difficult to weigh the value of these sprays and dusts. It is possible to make comparisons between the different sprays when applied to trees somewhat equal in infestation. From such a comparison it is evident that nicotine and fish oil gave better results than ammonia-valeriate. Likewise lead-arsenate gave better results when applied as a dust than calcium-arsenate. However, it is very evident that the light defoliations following treatments are closely associated with light infestation.

LEAD ARSENATE AND FISH OIL AS A REPELLENT TO OVIPOSITION

Recognizing that certain chemicals were repellent to the attacks of insects, it was thought that the application of lead arsenate and fish oil, as a stomach poison for the feeding larvae, might repell the adult moths and reduce, if not eliminate, oviposition upon the sprayed trees. To secure data relative to this possibility, a series of tip count examinations were made of trees which had been sprayed in 1930, but not in 1931, to determine the number of larvae per tip. As a check upon these data, tip examinations were also taken from trees that had not been treated in 1930 or 1931. It was hoped that the trees that had been sprayed in 1930 would show a much lighter infestation in 1931 than those which had not been treated, which would indicate that oviposition had not been so heavy. From the following tables it will be seen that this difference was so slight and so variable that the information secured was of rather doubtful value. However, in the four plots reductions varying from 4% to 18% were secured. It is recognized that the method used in determining the repellent qualities of this spray is subject to considerable error, as it was difficult to determine the actual number of larvae, or infested tips, which were on the trees during the year 1930. However, regardless of this fact, there was not a great deal of difference in the 1931 defoliation, which is a measurement of the intensity of oviposition, on the 1930 treated and untreated trees. It would seem that if this spray possessed very great repellent qualities there would have been a marked difference in the infestation of the trees treated and untreated the

previous season. In computing these data, 1930 records were used to determine the character of the coverage secured during that season, with the feeling that the better the coverage, the greater the repellent action and corresponding reduction in the infestation. However, no relationship seemed to exist between the different degrees of coverage. Several of the sprays applied this season may possess some repellent qualities and these plots will be followed during the coming season in an effort to determine such possibilities.

ELEPHANT HEAD

Basis	Status	Per cent of Tips Attacked	Status	Per cent of Tips Attacked	Reduction
5 Trees 1500 Tips	Sprayed 1930	94%	Unsprayed 1931	40%	54%
5 Trees 1500 Tips	Unsprayed 1930	98%	Unsprayed 1931	48%	50%

CHIMNEY ROCK

Basis	Status	Per cent of Tips Attacked	Status	Per cent of Tips Attacked	Reduction
4 Trees 1200 Tips	Sprayed 1930	92%	Unsprayed 1931	38%	54%
4 Trees 1200 Tips	Unsprayed 1930	88%	Unsprayed 1931	42%	46%

BLACKWATER CAMP

Basis	Status	Per cent of Tips Attacked	Status	Per cent of Tips Attacked	Reduction
5 Trees 1500 Tips	Sprayed 1930	94%	Unsprayed 1931	31%	63%
5 Trees 1500 Tips	Unsprayed 1930	96%	Unsprayed 1931	49%	47%

POWELL COLONY

Basis	Status	Per cent of Tips Attacked	Status	Per cent of Tips Attacked	Reduction
5 Trees 1500 Tips	Sprayed 1930	69%	Unsprayed 1931	72%	+3%
4 Trees 1200 Tips	Unsprayed 1930	79%	Unsprayed 1931	83%	+4%

DUDE RANCH AND SUMMER HOME SPRAYING - 1931

The following table shows the dude ranches and summer homes where the trees were sprayed during the 1931 operation. These trees were treated at a time when the foliage was thought to be in the very best condition for an application of spray, and it is believed that results as secured were fairly satisfactory. No detailed examinations were made of these trees; however, they were carefully observed and it is believed that the following table, though containing but general information, depicts existing conditions.

FORMULAE - Lead-arsenate 7-1/5#, 1 qt. Fish Oil, 120 gal. Water.

Name of Resort	Date Sprayed	Amount of Spray	Coverage	1931 Defoliation	General Condition of Trees
Lazy Bar H	June 8	1,000 gal.	Poor	Very light	Good
Martin's	June 8	400 gal.	Fair	Very light	Good
Blackwater Lodge	June 9	3,200 gal.	Fair	Light	Fair
Holm Lodge	June 15	10,000 gal.	Fair	Light	Good
Rumsey's	July 20	2,400 gal.	Fair	Medium	Fair
Elephant	July 21	1,800 gal.	Fair	Light	Good
Absoraka	July 21	2,400 gal.	Fair	Heavy	Fair
Kennedy	July 21	1,200 gal.	Fair	Light	Good
Artists' Colony	July 22	3,600 gal.	Fair	Heavy	Poor
Powell Colony	July 22	6,600 gal.	Fair	Heavy	Poor
Eagle Creek	July 22	1,800 gal.	Fair	Medium	Fair
Total		34,400 gal.			

GENERAL STATUS OF BUDWORM INFESTATION

In reporting the 1930 project it was stated that the 1930 defoliation was much lighter than that which had occurred in 1929. The continuation of this natural reduction was very evident during the past season, as the defoliation was much lighter than in 1930. It would seem that the outbreak of this insect within this region is at an end, and that its reduction has been due to its natural enemies. A great deal of defolintion is not expected during the 1932 season; however, it is recognized that one cannot be positive in making such a forecast. The insect will be present and in some small areas serious defoliation may result, but for the most part it is believed that the danger from the present outbreak of this insect has past.

GENERAL SUMMARY OF PROJECT

In determining the results secured from this series of experimental spraying tests, factors have been encountered which have made it a difficult task. The difference in the severity of the infestation of the different sample plots was perhaps the most important of these, though the condition of the foliage on the trees sprayed, as well as weather conditions encountered, contributed materially towards the variable results.

Though the factor of coverage is an important item in the results which are secured, in these tests this factor has of course been charged against the formulae used. Though rather easy to secure a good coverage on the old foliage, it still remained extremely difficult to produce similar conditions on the new needles. Perhaps the fact that the new needles are smoother and less resinous may explain this difficulty. Furthermore, as the larvae feed at the base of the needles, the location of the coverage secured must be considered in determining its effectiveness. Of the different sprays tested, with the various stickers and spreaders, the best coverage, though only recorded as fair, was secured from lead-arsenate and linseed oil, and lead-arsenate and pine oil.

It would seem that as a result of these tests, which are far from conclusive, due to the marked decline in the infestation, lead-arsenate and fish oil, or lead-arsenate and linseed oil, applied just as the buds are fully opened, will apparently give the most satisfactory results. A 3% solution of Volck applied as an ovicide might give even better results in preventing subsequent damage. Further tests of these sprays will need

be conducted against a more severe outbreak than that encountered last season before final conclusions can be drawn. The fact that during the first feeding of this insect the larvae are concealed within the buds makes it imperative that a stomach poison spray be applied just as the new growth is out sufficiently to permit the needles to be reached by the spray, if the damage to the trees is to be prevented. Obviously with a large scale operation it would be very difficult to spray all of the trees at a time when the optimum condition existed. For small areas, and for trees of high aesthetic values, it is believed that through the application of lead-arsenate and fish oil, or linseed oil, sufficient insects can be destroyed if the trees are sprayed at the right time to prevent a permanent injury.

PLAN FOR 1932 SEASON

With the decrease in the severity of the infestation within the Cody Canyon a detailed experimental plan of operation for the 1932 season is out of the question. Though a great deal of defoliation is not expected, it may prove necessary to spray the trees around some of the dude ranches. This situation should be carefully watched and if necessary the material which is on hand utilized in spraying any dangerous centers. Standard lead-arsenate and fish oil spray should be used.

In view of the results which have been secured, and the seriousness of the situation, it would perhaps be advisable to plan on spraying the following dude ranches: Holm Lodge, Black Water, Absorka, Elephant Head, Powell Colony, Rumseys, and Artist Colony. The following materials

would be required for such a program:

Name	600 Gallon Tanks	Lead Arsenate	Fish Oil	Labor
Holm Lodge	17	612	85 qts.	$ 42.00
Black Water	5	180	25 qts.	21.00
Absorka	4	144	20 qts.	12.00
Elephant Head	3	108	15 qts.	9.00
Powell Colony	11	396	55 qts.	32.00
Rumseys	4	144	20 qts.	16.00
Artist Colony	7	252	35 qts.	21.00
Totals	51	1,836	255	$ 153.00

There is sufficient fish oil on hand and 1250# of lead-arsenate. To conduct this program it will be necessary to secure some 600# of lead-arsenate, which would cost approximately $75.00. The labor might be handled by contributed labor from the Bureau of Entomology, Forest Service, and hose men donated by the dude ranch owners, or a small appropriation of $250.00 could be made which would purchase the necessary spray materials and provide the required labor. This would seem to be the most efficient procedure, and it is recommended that if moneys are available the sum of $250.00 be allotted for the purpose of conducting the spraying program as listed above. If this is not possible it is recommended that an effort be made to secure sufficient co-operative assistance from the owners of the dude ranches and summer homes, for which protection will be given, to

permit the institution of this program.

CONCLUSIONS

It is fully recognized that this is indeed a long detailed report for the amount of positive information which it contains. However, as it was necessary to work up the data secured, it was thought advisable to make the results secured, though primarily negative in character, a matter of permanent record.

Respectfully submitted,

James C. Evenden
Entomologist

PHOTOGRAPHS

#1 Spraying trees at Holm Lodge. Scenic value of trees to the property can be appreciated.

#2 Defoliated trees in front of sleeping cabin at Blackwater Lodge.

#3 Spraying tree around the sleeping cabins at Holm Lodge. Solid stream is being used to secure height. The scenic values of these trees is very evident.

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1.

2.

3.

PHOTOGRAPHS

#4 Spraying sample plot. Spreader on nozzle is being used to spray lower portion of the trees.

#5 Lead-arsenate and fish oil coverage secured on deciduous leaf.

#6 Lead-arsenate and fish oil coverage secured on last year's Douglas Fir needles.

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5.

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